Cyanobacteria blooms: effects on aquatic ecosystems

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Cyanobacteria increasingly dominate the plankton of lakes, rivers and estuaries as cultural eutrophication results in increased concentrations of phosphorus (P) and nitrogen (N) in the water column. Temporal dynamics of cyanobacteria blooms are quite variable – in some systems persistent blooms occur in summer to fall, whereas in other systems blooms are more sporadic. Surface blooms of taxa such as *Anabaena circinalis* and *Microcystis aeruginosa* are favored by high irradiance, a stable water column, low dissolved inorganic N, low free CO_2, and an abundant source of P at the sediment-water interface. Water column blooms of taxa such as *Oscillatoria agardhii* are favored by high P concentration and low underwater irradiance, and are most common in shallow eutrophic lakes. Cyanobacteria blooms have a wide range of biological impacts including potential toxic effects on other algae, invertebrates and fish, impacts to plants and benthic algae due to shading, and impacts to food web function as large inedible algae produce a bottleneck to C and energy flow in the plankton. In lakes with dense blooms of cyanobacteria, accumulation of organic material in lake sediments and increased bacterial activity leads to anoxic conditions that alter the structure of benthic macro-invertebrates. Diffusive internal P loading may increase, and hypolimnetic anoxia can lead to a loss of piscivorous fish that require a summer cold water refuge in temperate lakes. Ecosystem changes associated with frequent blooms may result in delayed response of lakes, rivers and estuaries to external nutrient load reduction and should be considered when modeling water quality scenarios for total maximum daily load (TMDL) and other regulatory processes.